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Summary of Surface-Water Quality, Ground-Water Quality, and Water Withdrawals for the Spirit Lake Reservation, North Dakota

Open-File Report 2006–1144

U.S. Department of the Interior
U.S. Geological Survey

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2006	**N/A**	**-**

4. TITLE AND SUBTITLE
Summary of Surface-Water Quality, Ground-Water Quality, and Water Withdrawals for the Spirit Lake Reservation, North Dakota

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of the Interior 1849 C Street, NW Washington, DC 20240

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
unclassified	**unclassified**	**unclassified**	**SAR**	**28**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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By Kevin C. Vining and Steven W. Cates

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Dirk Kempthorne, Secretary

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Conversion Factors and Datum

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
million gallons (Mgal)	3,785	cubic meter (m^3)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C = (°F - 32) / 1.8

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Glossary

Alluvial	Having been deposited by a stream or running water
Aquifer	Body of rock that has enough saturated permeable material to permit ground-water movement and yield economical amounts of water from wells
Coulee	Small stream that often flows intermittently
Glacial outwash	Coarse sediment material, mostly sand and gravel, that has been removed from a glacier by meltwater streams and deposited beyond the margin of the glacier
Glacial till	Unsorted materials deposited directly by a glacier without having been reworked by glacial meltwater
Loam soil	Soil that consists of nearly equal parts of sand, silt, and clay particles

Summary of Surface-Water Quality, Ground-Water Quality, and Water Withdrawals for the Spirit Lake Reservation, North Dakota

By Kevin C. Vining and Steven W. Cates[1]

Abstract

Available surface-water quality, ground-water quality, and water-withdrawal data for the Spirit Lake Reservation were summarized. The data were collected intermittently from 1948 through 2004 and were compiled from U.S. Geological Survey databases, North Dakota State Water Commission databases, and Spirit Lake Nation tribal agencies. Although the quality of surface water on the reservation generally is satisfactory, no surface-water sources are used for consumable water supplies. Ground water on the reservation is of sufficient quality for most uses. The Tokio and Warwick aquifers have better overall water quality than the Spiritwood aquifer. Water from the Spiritwood aquifer is used mostly for irrigation. The Warwick aquifer provides most of the consumable water for the reservation and for the city of Devils Lake. Annual water withdrawals from the Warwick aquifer by the Spirit Lake Nation ranged from 71 million gallons to 122 million gallons during 2000-04.

[1]Cates Earth Science Technologies.

1.0 Introduction

Water-quality and water-withdrawal data for the Spirit Lake Reservation are summarized

Data for the reservation were provided by State, Federal, and tribal agencies.

Knowledge about water resources on the Spirit Lake Reservation is needed to help tribal leaders make informed decisions about water-resources management. Therefore, the U.S. Geological Survey, in cooperation with the Spirit Lake Reservation, conducted a study to compile available surface-water quality, ground-water quality, and water-withdrawal data for the reservation. The data, which are summarized in this report, were collected intermittently from 1948 through 2004 and were compiled from U.S. Geological Survey databases, North Dakota State Water Commission databases, and Spirit Lake Nation tribal agencies. Results of the study will provide an improved understanding of water quality and water withdrawals on the reservation.

The Spirit Lake Reservation is located in northeastern North Dakota (fig. 1). The reservation encompasses an area of about 405 square miles in parts of Benson, Eddy, Nelson, and Ramsey Counties (Spirit Lake Dakotah Sioux Nation, 2005) and is bordered on the north by Devils Lake and on the south by the Sheyenne River. About 4,435 people reside on the reservation, and about 3,320 of those people are members of the Spirit Lake Nation (North Dakota Indian Affairs Commission, 2005).

Thanks are given to Silas Ironheart, Jr., Constance Baker, Oliver Gourd, Jr., David Azure, Jr., Frank Black Cloud, Sean Gourd, and Lorna Walking Eagle from the Spirit Lake Tribal EPA office and to Dave Cavanaugh and R. J. Yankton from the Spirit Lake Water Resource Management office for providing information and assisting in the preparation of this report.

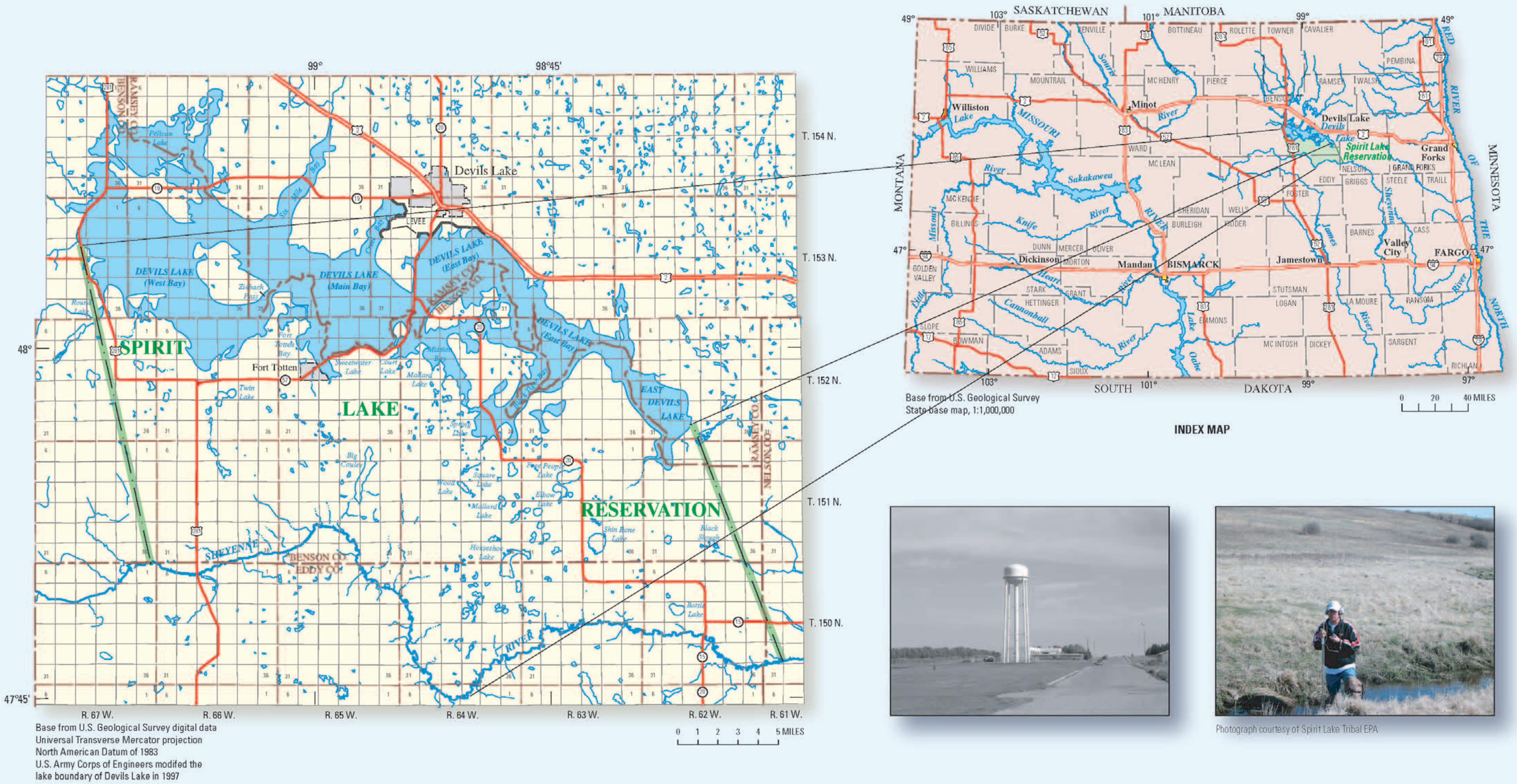


Figure 1. Location of Spirit Lake Reservation in North Dakota.

2.0 Climate

Long, cold winters and short, mild summers characterize the climate of the Spirit Lake Reservation

Average annual temperature was about 40 degrees Fahrenheit, and average annual precipitation was about 19.1 inches.

Average monthly and annual temperatures for the Spirit Lake Reservation were calculated from the distribution of 1971-2000 average monthly temperature data for selected National Weather Service cooperative stations (Golden Gate Weather Services, 2001). Average monthly temperatures for the reservation ranged from about 4 degrees Fahrenheit in January to about 70 degrees Fahrenheit in July, and the average annual temperature for 1971-2000 was about 40 degrees Fahrenheit (fig. 2). High temperatures at the National Weather Service cooperative station at Devils Lake have exceeded 110 degrees Fahrenheit, and low temperatures have reached -45 degrees Fahrenheit (High Plains Regional Climate Center, 2005).

Average monthly and annual precipitation for the Spirit Lake Reservation was calculated from the distribution of 1971-2000 average monthly precipitation data for selected National Weather Service cooperative stations (Golden Gate Weather Services, 2001). Average monthly precipitation for the reservation ranged from about 0.60 inch in January to about 3.25 inches in July, and average annual precipitation for 1971-2000 was about 19.1 inches (fig. 2). Annual precipitation on the reservation ranged from about 13.1 inches in 1988 to about 26.4 inches in 1994 (High Plains Regional Climate Center, 2005).

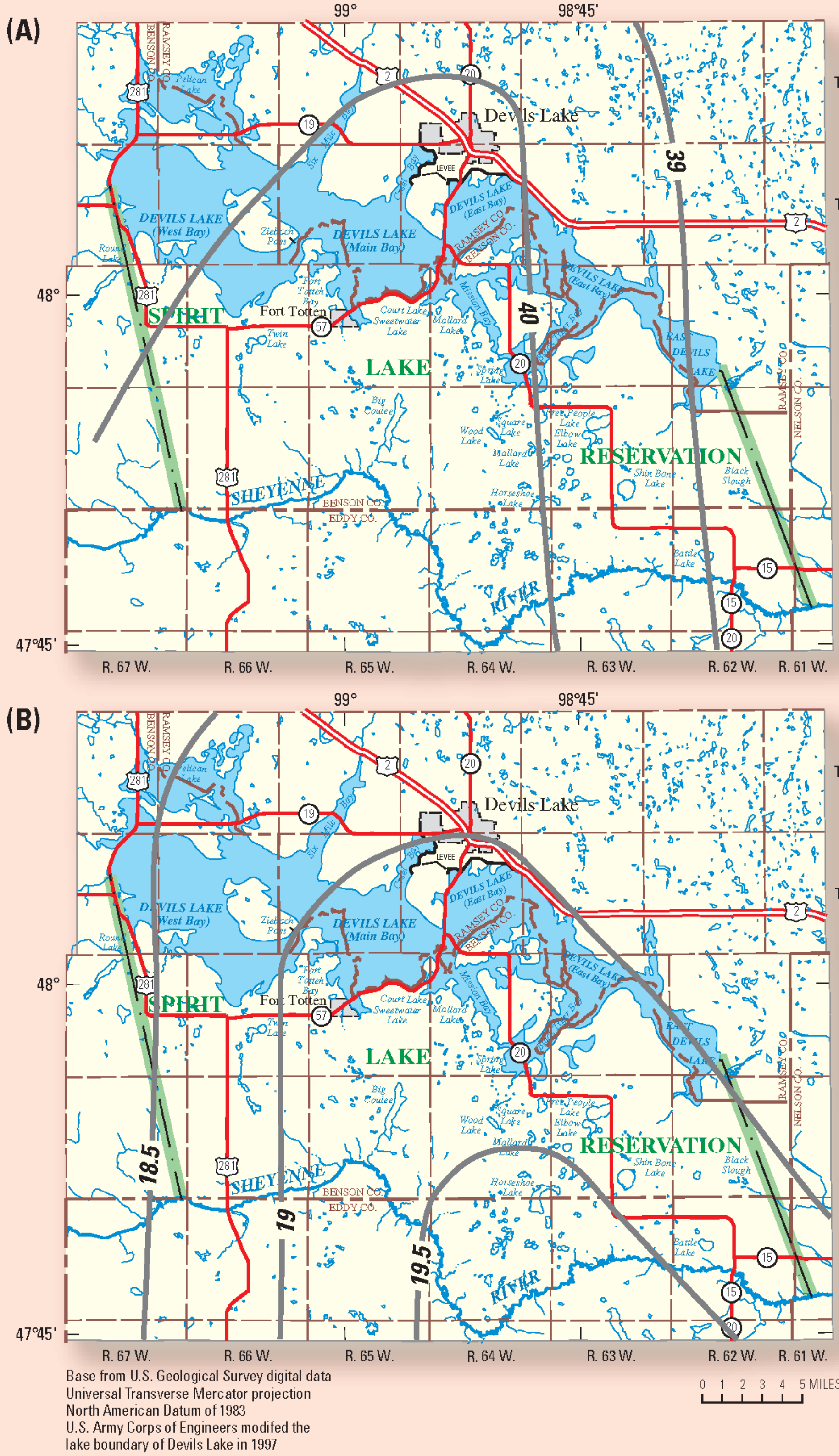


Figure 2. Average annual temperature (A), in degrees Fahrenheit, and average annual precipitation (B), in inches, for the Spirit Lake Reservation for 1971-2000.

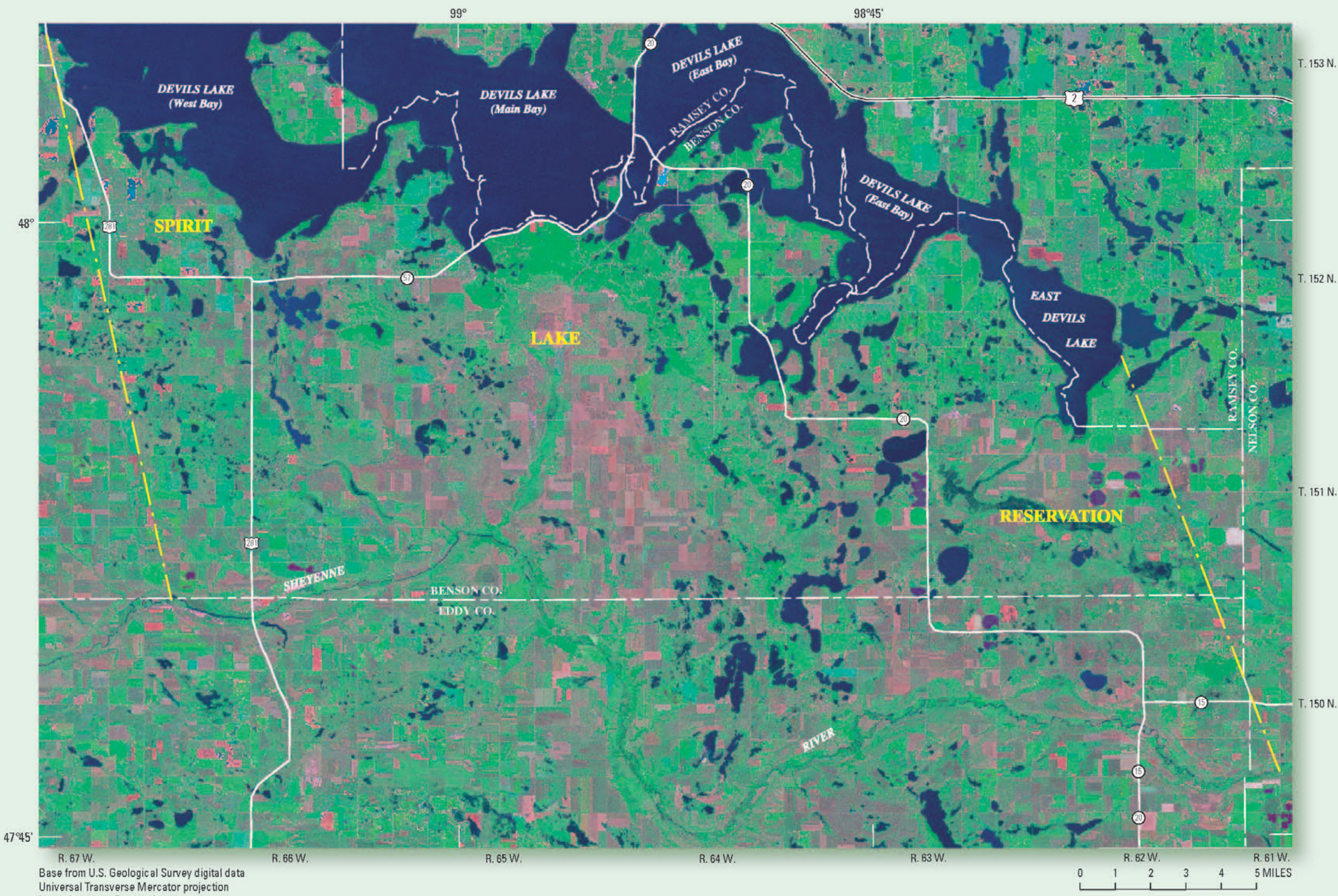
3.0 Topography and Land Use

Landforms on the Spirit Lake Reservation were created by glacial action

Most of the unforested land on the reservation is used for grazing and agriculture.

Landforms on the Spirit Lake Reservation were created by glacial erosion and deposition during several glacial periods. Land-surface elevations range from about 1,400 feet above the North American Vertical Datum of 1988 along the Sheyenne River to about 1,735 feet above the North American Vertical Datum of 1988 near Fort Totten (U.S. Geological Survey, 1950, 1951, 1962, 1994). Low rolling hills dominate the landscape throughout most of the reservation, and occasional forested areas occur among the grasslands and agricultural lands on the reservation and in the surrounding counties (Wright and Sweeney, 1977; Strum and others, 1979). Numerous semipermanent and permanent water bodies that vary in size are located throughout the reservation. The concentration of these water bodies is highest in the eastern part of the reservation.

Most of the land on the reservation is used for grazing and agriculture as shown by the regular pattern of the land surface in figure 3. However, some land is used only for grazing, and some land, especially near Devils Lake, is forested. Soil characteristics of the agricultural areas indicate the soils are mostly good to fair for agricultural production (Strum and others, 1979). Wheat, barley, corn, soybeans, sunflowers, and hay are the major crops on the reservation, and some irrigation occurs in the southeastern part of the reservation (U.S. Department of Agriculture, 2006).



Base from U.S. Geological Survey digital data
Universal Transverse Mercator projection
North American Datum of 1983
Landsat enhanced Thematic Mapper Image of Spirit Lake Reservation, August 5, 2002

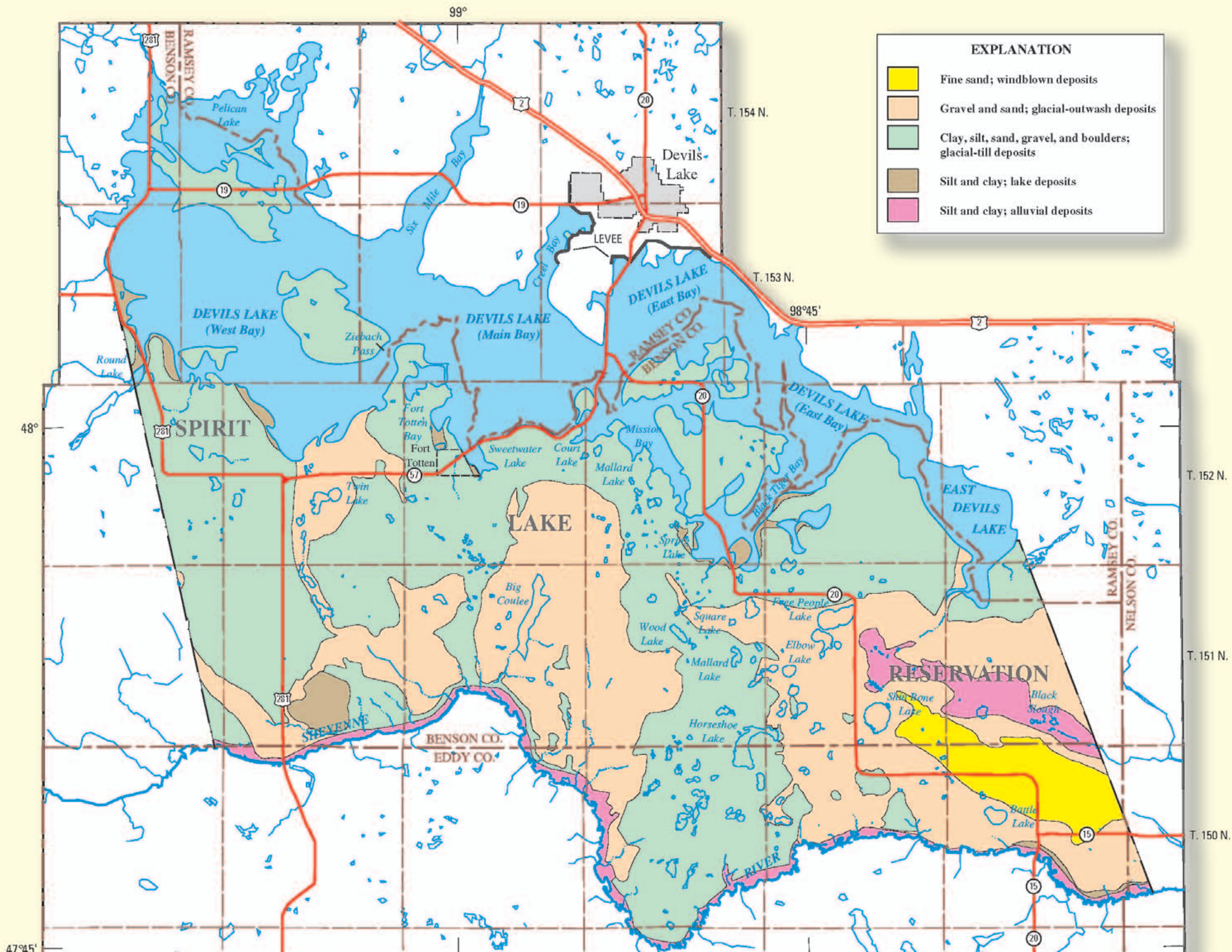
Figure 3. Satellite photograph of the Spirit Lake Reservation.

4.0 Basic Surficial Geology

The surficial geology of the Spirit Lake Reservation was defined by glacial activity

Surface materials on the reservation consist of a mixture of clay, silt, sand, gravel, and boulders.

The geology of the Spirit Lake Reservation was defined by glacial activity (Bluemle, 1965, 1973; Carlson and Freers, 1975; Hobbs and Bluemle, 1987). Glaciers moved from north to south across the northeastern part of North Dakota and pushed rocks, soils, and other materials onto the area of the reservation. Rock materials underlying the area of glaciation were mixed with clays, silts, sands, gravels, and boulders carried by the glaciers in the form of glacial till. As the glaciers melted and retreated, the glacial till was left behind and meltwater moved and redeposited some of the glacial sands and gravels as glacial-outwash and silt and clay alluvial deposits (fig. 4). A few areas of silt and clay lake deposits formed along Devils Lake and in a large depression in the southwestern corner of the reservation. Many of the glacial and alluvial deposits are several hundred feet thick. Some windblown deposits of fine sand also occur on the surface in the southeastern part of the reservation.



Base from U.S. Geological Survey digital data
Universal Transverse Mercator projection
North American Datum of 1983
U.S. Army Corps of Engineers modifed the lake boundary of Devils Lake in 1997

0 1 2 3 4 5 MILES

Geology by C.G. Carlson and T.F. Freers, 1975

Photograph courtesy of Spirit Lake Tribal EPA

Figure 4. Basic surficial geology of the Spirit Lake Reservation.

5.0 Surface-Water Quality—Major Constituents

Average major-constituent concentrations are given for surface-water bodies on the Spirit Lake Reservation

Surface-water quality on the reservation generally is satisfactory.

Surface-water quality data compiled from U.S. Geological Survey databases were used to describe the quality of surface water on and near the Spirit Lake Reservation. Surface-water locations that were sampled include Devils Lake, the Sheyenne River, and the numerous small lakes and wetlands that occur on the reservation. The water-quality data, which were collected intermittently from 1948 through 2004, were divided into five groups—data for Devils Lake, data for the Sheyenne River, data for small lakes and wetlands in the western and northern parts of the reservation, data for small lakes and wetlands overlying the Tokio aquifer, and data for small lakes and wetlands overlying the Warwick aquifer. For each of the five groups, average calcium, magnesium, sodium, sulfate, and chloride concentrations were determined without consideration for the time of sample collection, the location of the sampling site, or the number of samples collected.

Devils Lake, the small lakes and wetlands in the western and northern parts of the reservation, and the small lakes and wetlands overlying the Warwick aquifer had similar average dissolved-solids concentrations (fig. 5). The Sheyenne River had average concentrations that were generally lower than those for the remaining four groups (fig. 5). Although the quality of surface water on the reservation generally is satisfactory, no surface-water sources are used for consumable water supplies.

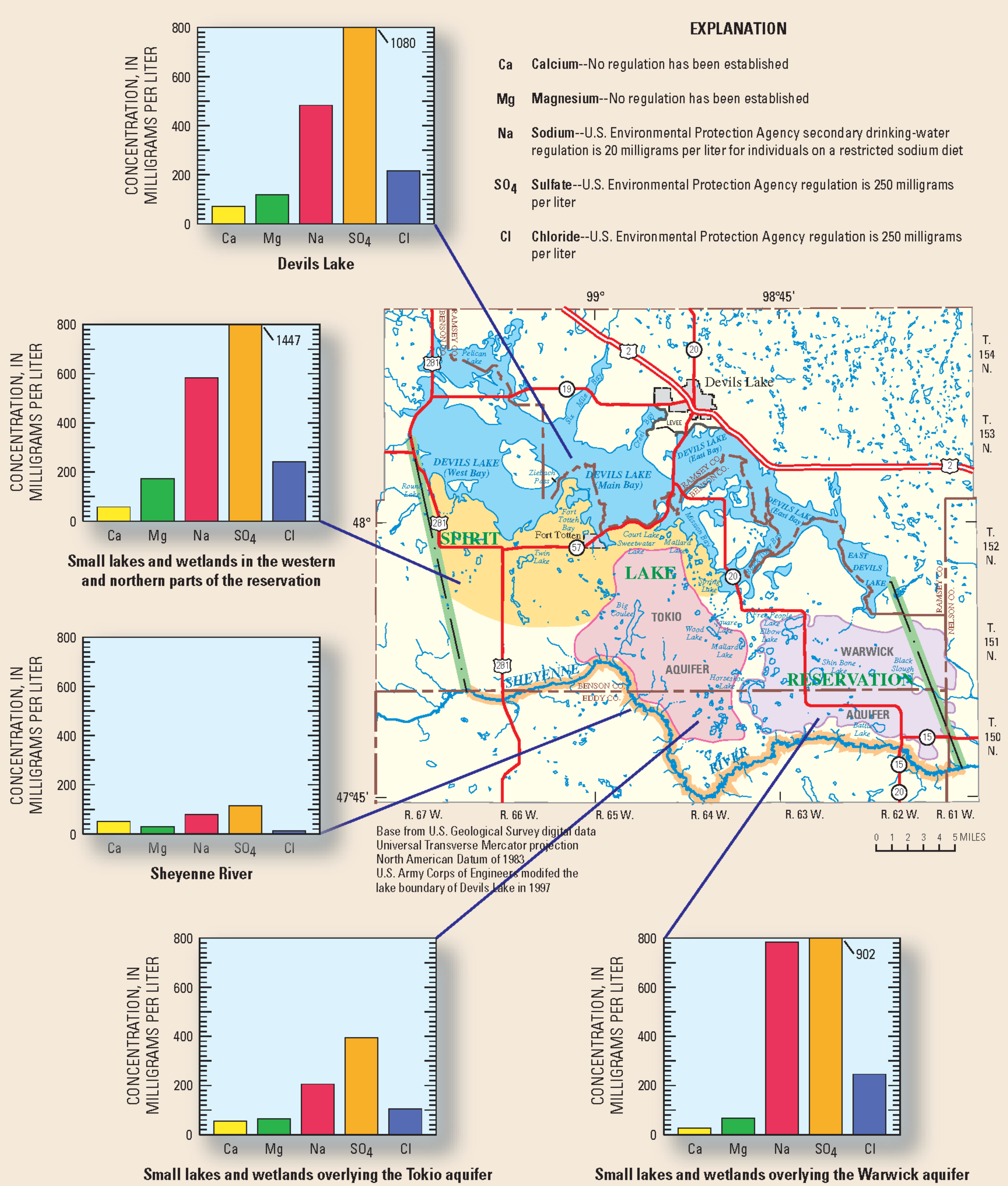


Figure 5. Average calcium, magnesium, sodium, sulfate, and chloride concentrations for Devils Lake, the Sheyenne River, and small lakes and wetlands on the Spirit Lake Reservation. (Data were collected intermittently from 1948 through 2004.)

6.0 Surface-Water Quality—Trace Elements

Trace-element concentrations are given for surface-water bodies on the Spirit Lake Reservation

Many concentrations were greater than U.S. Environmental Protection Agency regulations.

Surface-water quality data compiled from U.S. Geological Survey databases were used to describe the quality of surface water on and near the Spirit Lake Reservation. The water-quality data, which were collected intermittently from 1948 through 2004, were divided into five groups—data for Devils Lake, data for the Sheyenne River, data for small lakes and wetlands in the western and northern parts of the reservation, data for small lakes and wetlands overlying the Tokio aquifer, and data for small lakes and wetlands overlying the Warwick aquifer. Arsenic, boron, manganese, mercury, and selenium concentrations for surface-water samples collected from surface-water bodies in the five groups are shown in figure 6.

The five groups had many arsenic, boron, and manganese concentrations that exceeded U.S. Environmental Protection Agency (2004) regulations for those constituents but no selenium concentrations that exceeded the regulation for that constituent. The Sheyenne River had a few mercury concentrations that exceeded the U.S. Environmental Protection Agency (2004) regulation for that constituent. Arsenic, boron, manganese, mercury, and selenium probably occur naturally, to some extent, in the rocks and soils in North Dakota and on the Spirit Lake Reservation, and some trace elements may be released during the burning of coal. Other trace elements have been detected in surface-water bodies on the reservation, but too few data were available to include figures for those elements.

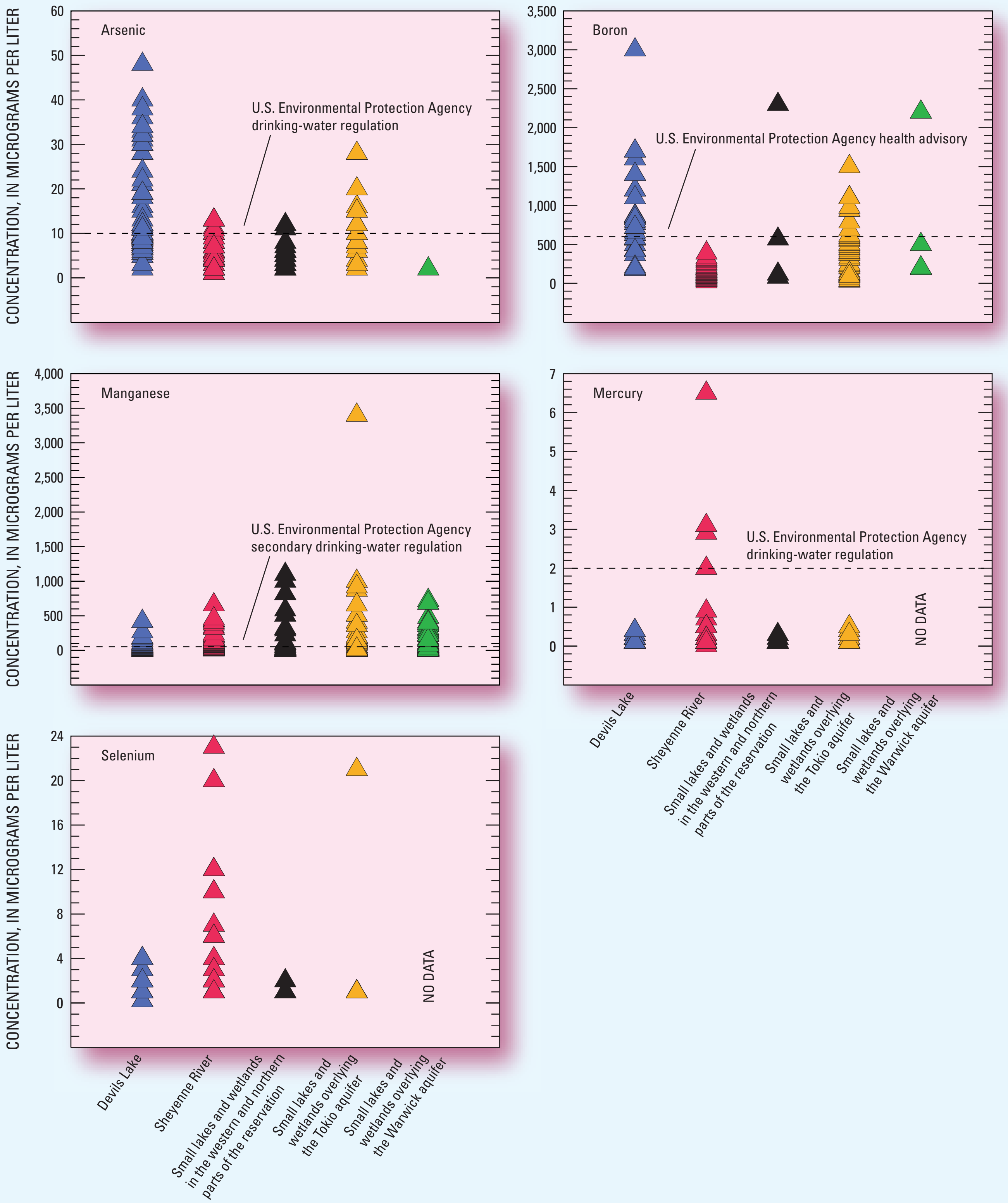


Figure 6. Arsenic, boron, manganese, mercury, and selenium concentrations for surface-water samples collected from Devils Lake, the Sheyenne River, and small lakes and wetlands on the Spirit Lake Reservation.

7.0 Ground-Water Quality—Major Constituents

Average major-constituent concentrations are given for three major aquifers underlying the Spirit Lake Reservation

Ground water on the reservation is of sufficient quality for most uses.

Ground-water quality data compiled from U.S. Geological Survey databases were used to describe the quality of ground water underlying the Spirit Lake Reservation. Ground-water samples were obtained from the Tokio and Warwick aquifers, which underlie areas in the southeastern part of the reservation, and from the Spiritwood aquifer, which underlies areas in the northern and eastern parts of the reservation (fig. 7). The water-quality data, which were collected intermittently from 1948 through 2004, were divided into three groups—data for the Tokio aquifer, data for the Warwick aquifer, and data for the Spiritwood aquifer. Average calcium, magnesium, sodium, sulfate, and chloride concentrations were determined without consideration for the time of sample collection, the location of the sampling site, or the number of samples collected.

The Tokio and Warwick aquifers have better overall water quality than the Spiritwood aquifer as indicated by the lower average concentrations for those aquifers (fig. 7). Therefore, water from the Spiritwood aquifer appears to be less desirable as a consumable water supply. Water from the Tokio aquifer and from the Warwick aquifer has a lower average sodium concentration than water from the Spiritwood aquifer (fig. 7), making water from the Tokio and Warwick aquifers more desirable for irrigation.

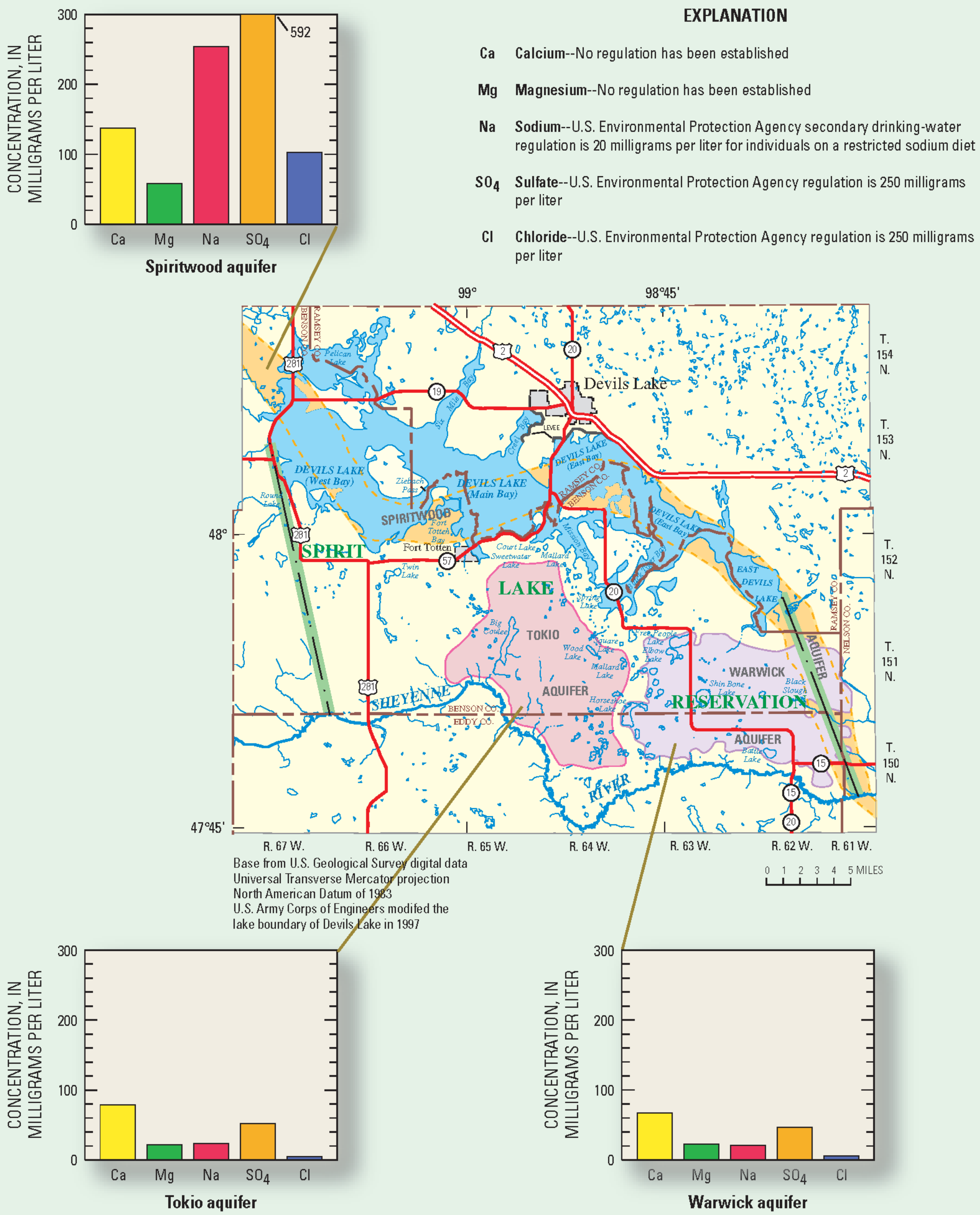


Figure 7. Average calcium, magnesium, sodium, sulfate, and chloride concentrations for ground-water samples collected from the Tokio, Warwick, and Spiritwood aquifers underlying the Spirit Lake Reservation. (Data were collected intermittently from 1948 through 2004.)

8.0 Ground-Water Quality—Trace Elements

Trace-element concentrations are given for three major aquifers underlying the Spirit Lake Reservation

Many concentrations were greater than U.S. Environmental Protection Agency standards.

Ground-water quality data compiled from U.S. Geological Survey databases were used to describe the quality of ground water underlying the Spirit Lake Reservation. The water-quality data, which were collected intermittently from 1948 through 2004, were divided into three groups—data for the Tokio aquifer, data for the Warwick aquifer, and data for the Spiritwood aquifer. Arsenic, boron, manganese, mercury, and selenium concentrations for ground-water samples collected from the three aquifers are shown in figure 8.

The three groups had many arsenic, boron, and manganese concentrations that exceeded U.S. Environmental Protection Agency (2004) regulations for those constituents but no mercury and selenium concentrations that exceeded the regulations for those constituents. Arsenic, boron, manganese, mercury, and selenium probably occur naturally, to some extent, in the rocks and soils in North Dakota and on the Spirit Lake Reservation, and some trace elements may be released during the burning of coal. Other trace elements have been detected in ground-water aquifers underlying the reservation, but too few data were available to include figures for those elements.

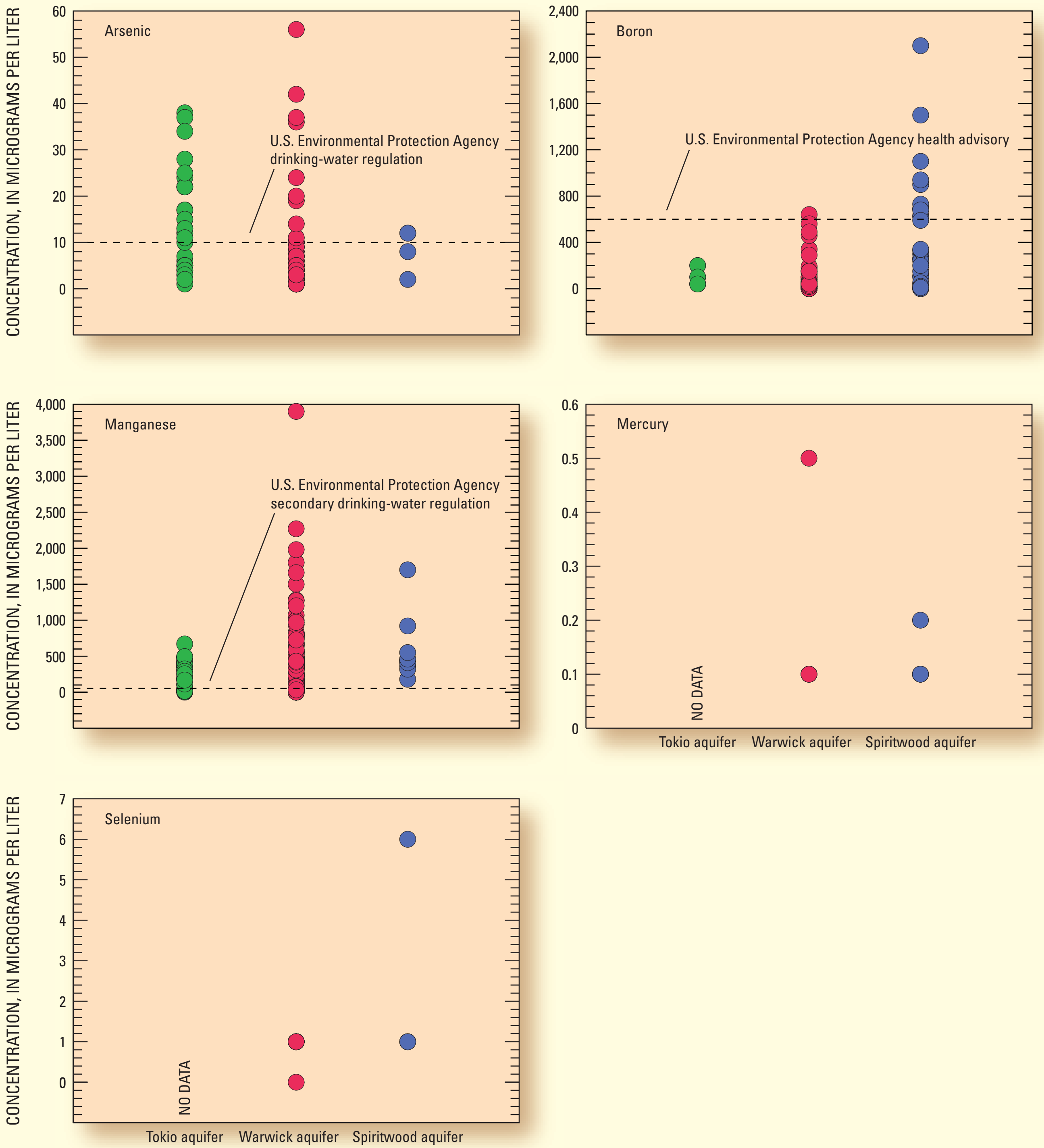


Figure 8. Arsenic, boron, manganese, mercury, and selenium concentrations for water samples collected from the Tokio, Warwick, and Spiritwood aquifers underlying the Spirit Lake Reservation.

9.0 Water Withdrawals

Water withdrawals from aquifers underlying the Spirit Lake Reservation vary with weather conditions

Water use by the Spirit Lake Nation has been slowly increasing since 2000.

Irrigation water on the reservation is withdrawn mostly from the Warwick and Spiritwood aquifers. The amounts of water withdrawn for irrigation have varied considerably from year to year because of varying amounts of rainfall (fig. 9). Withdrawals for irrigation were large during 1988-89 because of dry weather conditions during that period. However, generally wet weather conditions since 1992 have resulted in decreased withdrawals for irrigation because greater amounts of rainfall usually result in less irrigation demand. According to Schuh (1999), a significant amount of acreage suitable for additional irrigation development overlies the Warwick aquifer. Most of the acreage consists of sand and loam soils that are considered potentially suitable for irrigation.

Annual water withdrawals from the Warwick aquifer for consumption by the city of Devils Lake ranged from 256 million gallons to 432 million gallons during 1981-2004 (fig. 9). Withdrawals peaked in 1992 and 1993 and then generally decreased from 1995 through 2004.

Annual water withdrawals from the Warwick aquifer by the Spirit Lake Nation ranged from 71 million gallons to 122 million gallons during 2000-04 (fig. 9) (R. J. Yankton, Spirit Lake Water Resource Management, written commun., 2005). According to R. J. Yankton with the Spirit Lake Water Resource Management office, the larger amount of water withdrawn in 2003 probably resulted from a leak in the reservation water system.

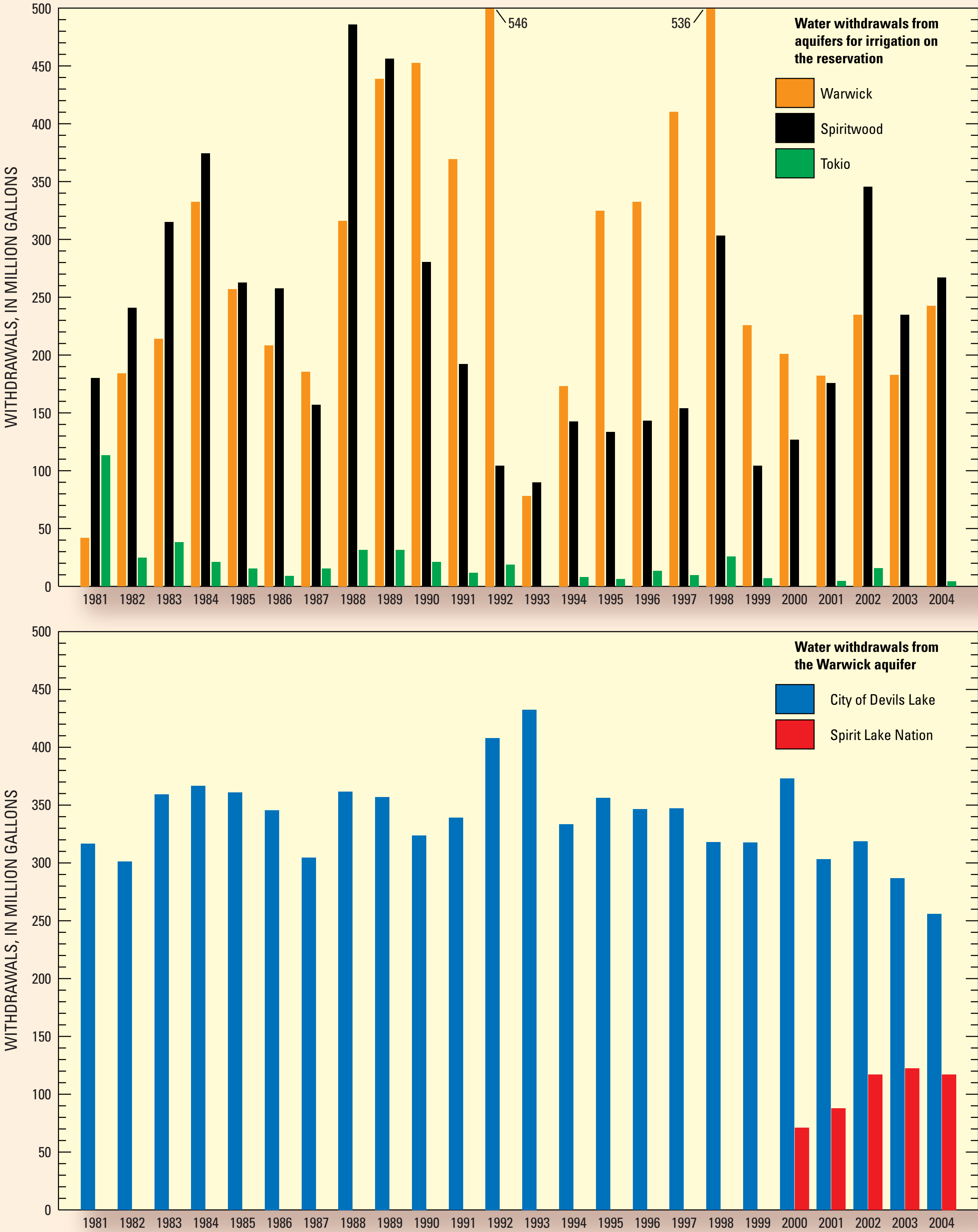


Figure 9. Annual water withdrawals from the Tokio, Warwick, and Spiritwood aquifers underlying the Spirit Lake Reservation.

10.0 Selected References

Bluemle, J.P., 1965, Geology and ground water resources of Eddy and Foster Counties, North Dakota, Part I, Geology: North Dakota Geological Survey 44 and North Dakota State Water Commission County Ground Water Studies 5, 66 p.

Bluemle, J.P., 1973, Geology of Nelson and Walsh Counties, North Dakota Geological Survey Bulletin 57, pt. I, and North Dakota State Water Commission County Ground Water Studies 17, pt. I, 69 p.

Carlson, C.G., and Freers, T.F., 1975, Geology of Benson and Pierce Counties, North Dakota: North Dakota Geological Survey Bulletin 59, pt. I, and North Dakota State Water Commission County Ground Water Studies 18, pt. I, 32 p.

Downey, J.S., 1971, Ground-water basic data, Nelson and Walsh Counties, North Dakota: North Dakota Geological Survey Bulletin 57, pt. II, and North Dakota State Water Commission County Ground-Water Studies 17, pt. II, 459 p.

Downey, J.S., 1973, Ground-water resources, Nelson and Walsh Counties, North Dakota: North Dakota Geological Survey Bulletin 57, pt. III, and North Dakota State Water Commission County Ground-Water Studies 17, pt. III, 67 p.

Golden Gate Weather Services, 2001, North Dakota climate normals (1971-2000): accessed June 2005 at http://ggweather.com/normals/ND.htm

High Plains Regional Climate Center, 2005, Climate data—Holdings and services: accessed June 2005 at http://www.hrpcc.unl.edu/data.htm

Hobbs, H.C., and Bluemle, J.P., 1987, Geology of Ramsey County, North Dakota: North Dakota Geological Survey Bulletin 71, pt. I, and North Dakota State Water Commission County Ground Water Studies 26, pt. I, 69 p.

Hutchinson, R.D., 1977, Ground-water basic data for Ramsey County, North Dakota: North Dakota Geological Survey Bulletin 71, pt. II, and North Dakota State Water Commission County Ground-Water Studies 26, pt. II, 344 p.

Hutchinson, R.D., and Klausing, R.L., 1980, Ground-water resources of Ramsey County, North Dakota: North Dakota Geological Survey Bulletin 71, pt. III, and North Dakota State Water Commission County Ground-Water Studies 26, pt. III, 36 p.

North Dakota Department of Health, 1994, Public water supply systems in North Dakota, chapter 33-17-01: Bismarck, North Dakota, 43 p.

North Dakota Indian Affairs Commission, 2005, Statistics—North Dakota's first nations: accessed December 2005 at http://www.health.state.nd.us/ndiac/statistics.htm

Paulson, Q.F., and Akin, P.D., 1964, Ground-water resources of the Devils Lake area, Benson, Ramsey, and Eddy Counties, North Dakota, N.D.S.W.C. Project No. 747: North Dakota Ground-Water Studies No. 56, 211 p.

Pusc, S.W., 1992a, Ground-water data: The interaction between ground water and a large terminal lake, Devils Lake, North Dakota: North Dakota State Water Commission Water-Resources Investigation 13, p. 65.

Pusc, S.W., 1992b, Water supply investigation for the Ramsey rural water project portions of Benson, Ramsey, Eddy, and Nelson Counties, North Dakota: North Dakota State Water Commission Ground-Water Studies Number 100, p. 441.

Radig, S.A., 1997, Warwick aquifer—LEPA irrigation monitoring project: North Dakota Department of Health Division of Water Quality, 48 p.

Randich, P.G., 1971, Ground-water basic data, Benson and Pierce Counties, North Dakota: North Dakota Geological Survey Bulletin 59, pt. II, and North Dakota State Water Commission County Ground-Water Studies 18, pt. II, 360 p.

Randich, P.G., 1977, Ground-water resources of Benson and Pierce Counties, North Dakota: North Dakota Geological Survey Bulletin 59, pt. III, and North Dakota State Water Commission County Ground-Water Studies 18, pt. III, 76 p.

Reed, T.B., 1997, Digital simulation of ground-water flow in the Warwick aquifer, Fort Totten Indian Reservation, North Dakota: U.S. Geological Survey Water-Resources Investigations 97-4114, 51 p.

Reed, T.B., 1998, Vulnerability of ground water in the Tokio and Warwick aquifers to surface contamination, Fort Totten Indian Reservation, North Dakota: U.S. Geological Survey Water-Resources Investigations 98-4152, 30 p.

Schuh, W.M., 1999, Assessment of potentially irrigable land in the area of the Warwick aquifer in Benson, Eddy, and Nelson Counties, North Dakota: North Dakota State Water Commission, 53 p.

Spirit Lake Dakotah Sioux Nation, 2005, Spirit Lake Tribe: accessed December 2005 at http://www.spiritlakenation.com/about.htm

Strum, J.F., Heidt, C.J., and Bigler, R.J., 1979, Soil survey of Benson County area, North Dakota: U.S. Department of Agriculture, Soil Conservation Service, and U.S. Department of the Interior, Bureau of Indian Affairs, 245 p.

Trapp, H., Jr., 1966, Geology and ground water resources of Eddy and Foster Counties, North Dakota, Part II, Ground water basic data: North Dakota Geological Survey Bulletin 44 and North Dakota State Water Conservation Commission County Ground Water Studies 5, 243 p.

Trapp, H., Jr., 1968, Geology and ground water resources of Eddy and Foster Counties, North Dakota, Part III, Ground water resources: North Dakota Geological Survey Bulletin 44 and North Dakota State Water Conservation Commission County Ground Water Studies 5, 110 p.

U.S. Department of Agriculture, 2006, North Dakota county data--Crops: accessed May 2006 at http://www.nass.usda.gov:8080/QuickStats/Create_County_All.jsp

U.S. Environmental Protection Agency, 2004, 2004 edition of the drinking water standards and health advisories: Washington, D.C., Office of Water, U.S. Environmental Protection Agency, EPA 822-R-04-005, 20 p.

U.S. Geological Survey, 1950, 1951, 1962, 1994, Topographic maps 1:24,000 scale: Series V871.

Vining, K.C., 1997, Water-quality assessments of ground water and surface water in the Warwick aquifer area, Fort Totten Indian Reservation, North Dakota: U.S. Geological Survey Open-File Report 97-201, 18 p.

Wright, M.R., and Sweeney, M.D., 1977, Soil survey of Eddy County and parts of Benson and Nelson Counties, North Dakota: U.S. Department of Agriculture, Soil Conservation Service, and U.S. Department of the Interior, Bureau of Indian Affairs, 202 p.

Appendix 1. Drinking-water regulations, common sources, and significant effects for selected properties and constituents.

[Regulations are from U.S. Environmental Protection Agency, 2004; mg/L, milligrams per liter; µg/L, micrograms per liter]

Property or constituent	Drinking-water regulation	Common sources	Significant effects
pH	6.5 to 8.5 standard units[1]	A measure of hydrogen-ion activity. Can be affected by geologic setting, biological activity, municipal and industrial wastewater discharge, and atmospheric conditions.	Low pH water can cause corrosion, enhance release of other metals into water, and cause metallic taste. High pH water can give water a soda taste and result in accumulation of deposits.
Dissolved solids	500 mg/L[1]	A result of rock weathering, agricultural runoff, and industrial discharge.	Excess dissolved solids can harm aquatic organisms and cause water to be unsuitable as a public, agriculture, and industry supply.
Sulfate	250 mg/L[1]	Occurs in some rocks. Also occurs in mine runoff, industrial wastewater discharge, and atmospheric deposition.	Excess amounts can harm aquatic organisms.
Chloride	250 mg/L[1]	Occurs in some rocks and ground-water discharge. Also occurs in road deicers, industrial and urban wastewater discharge, and atmospheric deposition.	Excess amounts can cause water to be unsuitable as a public, agriculture, and industry supply. Can harm aquatic organisms.
Arsenic	10 µg/L	Found in sulfide ore deposits, volcanic gases, and geothermal water. Is used in some pesticides.	Causes problems with skin and circulatory system. Increases risk of cancer.
Barium	2 mg/L	Erosion of natural deposits. Occurs in mine runoff and refinery wastewater discharge.	Causes increase in blood pressure.
Boron	600 µg/L[2]	Found in volcanic gases, geothermal springs, and minerals associated with some igneous rocks. Used in fertilizers and cleaning products.	Small amounts are essential in plant growth.
Cadmium	5 µg/L	Present in zinc ore minerals. Produced by metal refineries and discarded batteries.	May cause kidney damage.
Chromium	100 µg/L	Produced by erosion from natural deposits, fossil fuel combustion, and discharge from steel and pulp mills.	Binds to soil sediments. Accumulates in living tissue. Causes dermatitis and liver and kidney damage.
Lead	15 µg/L[3]	Occurs from erosion of natural deposits. Had been used as gasoline additive.	Causes mental development problems in children and kidney damage in adults.
Manganese	50 µg/L[1]	Found in many igneous and metamorphic minerals, organic deposits, and geothermal springs. Also used in fertilizers.	Essential element in plant metabolism. Can discolor water and produce a bitter, metallic taste.
Mercury	2 µg/L	Once used in pesticides. Also a byproduct of smelting and fossil-fuel combustion.	Causes kidney damage. Can accumulate in animals high in the food chain such as predatory fish and birds.
Selenium	50 µg/L	Produced by erosion of natural deposits, petroleum refining, and mining.	Accumulates in tissues, causing nervous and circulatory problems. Becomes more available for plant uptake in alkaline soils.

[1]U.S. Environmental Protection Agency (2004) secondary drinking-water regulation.

[2]U.S. Environmental Protection Agency (2004) health advisory.

[3]U.S. Environmental Protection Agency (2004) treatment technique action level.

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